Optimizing Value in Comparing Materials and Systems

Thorough evaluation of alternate materials and systems can lead to incredible value for all stakeholders.

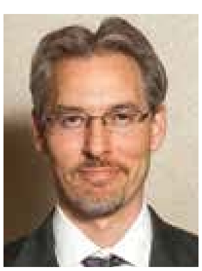
— Brian Miller, PE, LEED AP

It is common in the construction industry to compare different or alternate options of construction methods. Even after a design is completed, there may be alternates submitted to change one system, or material, for another. There are many benefits to this such as finding materials that perform better, look better, reduce life-cycle costs, increase the overall value, and in some cases, even reduce first costs. However, the difficult part is performing a complete and fair evaluation between options. Often this is rushed or made to be too simplistic, leaving a lot of value, including money, on the table. This article discusses several of the interrelationships and approaches to conducting a thorough evaluation.

The Simple Substitution Approach

The easiest and unfortunately most common approach is to simply substitute one specific material for another. For example, if we were building a single-family, traditional stick-framed home that was to be finished with brick veneer, and the owner requested an evaluation to change to stone veneer instead. In the simple substitution approach we would look at the material and labor costs associated with the brick veneer compared to stone veneer. Hypothetically, if the stone veneer was $15 per square foot and the brick veneer was $12 per square foot, we could determine that the stone veneer costs $3 per square foot more and submit a change order for the cost difference increase. However, this is only part of the evaluation. For example, what about the foundation that no longer needs to include a 4-inch brick ledge? The stone veneer will transfer its load into the stick-framed wall, whereas the brick would have gravity loaded onto the foundation walls. The smaller foundation requires less concrete, as well as smaller footers, etc.; this would result in a cost savings which should be taken into account as well.

The decision to switch one material for another rarely impacts only one system or component of the project. To truly understand the impact, one must evaluate the interrelation between systems, as well as schedule, effect on revenue generation (for commercial projects), operational costs (e.g., energy to heat and cool), maintenance costs, etc. While this may require more time, it is the only way to truly optimize a structure and its performance.



– Brian Miller has more than 25 years of experience in the construction industry. Prior to joining PCI, Miller has served in the capacity of president of a design-build construction company, as well as in the roles of director of technical services, project manager, project engineer, and field manager

High-Performance Approach

Buildings are a compilation of complex and integrated systems. Designers and contractors must understand how these systems interrelate in order to achieve project optimization and deliver high-performance structures. This includes a high-performance approach to evaluating one material to another. Here are some suggestions on how to truly compare and evaluate different materials and systems.

First, start by creating a list of systems and project components to investigate. Table 1 contains a sample list that is rooted in the definition of high-performance structures. This definition challenges us to optimize all relevant attributes for a structure. Hence, we must consider the impact on these systems with a material change. Realizing however that each project is unique, the list could be modified for your project's specifics. The main idea here is to think "out of the line item box" and more holistically about the project and its operations. We should also keep in mind that high-performance structures challenge us to evaluate structures and costs from a long-term, life-cycle perspective, not just a first-cost approach.

Table 1—Sample List of Items to Consider when comparing materials or systems.

Project Schedule	**Speed up or delay?**
Foundation Systems	**Design changes required? Does it make it smaller or bigger?**
Site Impact (storage, staging, waste, etc.)	**More or less?**
HVAC Systems & Other MEP	**Does it change heating & cooling loads? System(s) installation?**
Operational Costs (e.g. energy consumption)	**How does the change affect the projected energy consumption?**
Maintenance	**More or less? Costs increase or decrease?**
Structural Systems	**Change in loads, connections, etc.**
Envelope Systems	**Does it affect the envelope? Air barrier? Vapor barrier? Thermal bridging?**
Elevator Systems	**Does it affect the elevators or transit systems?**
Use Adaptability	**Does it make it easier to change use, or harder?**
Project Aesthetics	**Does is accomplish the aesthetic goal(s)?**
Environmental Impacts	**More or less?**
Indoor Environmental Quality	**Does it improve or reduce IEQ?**
Revenue Generation	**Linked to schedule, does the project complete faster? If so, what is the revenue/per week for the owner? Does is decrease the construction loan amount or period?**
Design and Construction Complexity	**Does it make it easier to design and construct? Is the change adding trades, detailing, connections, and maintenance concerns?**
Risk Management	**Increasing or reducing risks? Liability for designer, contractor, owner, public, occupants?**
Durability and Resiliency	**Is the change improving durability? Is it improving resiliency? Does it increase service life?**

Next, determine if the material change has any affect or interaction with the items in Table 1. If yes, then try to quantify, or at least qualify the effect. Most of these can be translated into dollars, but assumptions should be stated and maintained for all comparisons.

Let's look at an actual project as an example to apply. Table 2 contains a comparison for a 120,000 square-foot, eight-story, dormitory project. High-performance insulated precast wall panels with embedded thin-brick were compared as an alternate to traditional field-laid brick veneer and block CMU. The structural system was cast-in-place concrete for both envelope options.

The precast envelope system option saved 60 days, and $1,200,000 of first costs.

Table 2—Insulated, Embedded Thin-brick Precast Compared to Field-laid Brick Veneer.

Project Schedule — Speed up or delay?	Precast saved 40 days from the project schedule. Reduced cost of general conditions.
Foundation Systems — Design changes required? Does it make it smaller or bigger?	Foundation size increased 2%.
Site Impact (storage, staging, waste, etc.) — More or less?	The site impact was significantly reduced, e.g., no scaffolding was needed. There was a reduction in site clean-up after project completion as well.
HVAC Systems & Other MEP — Does it change heating & cooling loads?	HVAC contractors used the performance R-value of R-26, which reduced the size of the HVAC equipment by 30% = $500,000 in first-cost savings.
Operational Costs (e.g. energy consumption) — How does the change effect the projected energy consumption?	Energy modeling or actual data shows the annual energy costs to be reduced by 40%, relative to the baseline code. This results in an approximate annual savings of $38,000 per year based on the cost of natural gas.
Maintenance — More or less? Costs increase or decrease?	Precast system reduced total number of joints, flashing, etc. The project was completed four years ago, and has required no maintenance. Maintenance costs are projected to be reduced by 10%, or approximately $20,000 per year.
Structural Systems — Change in loads, connections, etc.	The load-bearing precast wall system eliminated the need for redundant exterior columns saving about $650,000 in construction costs, and adding 1.2% more usable floor space.
Envelope Systems — Does it affect the envelope? Air barrier? Vapor barrier? Thermal bridging?	Improved energy performance by providing continuous insulation (ci), eliminated thermal bridging, provided vapor barrier, and thermal mass—resulted in material R-value of R-14.25, performance R-value 26.
Elevator Systems — Does it affect the elevators or transit systems?	No effect.
Use Adaptability — Does it make it easier to change use, or harder?	The precast envelope eliminated exterior columns, which increased usable floor space.
Project Aesthetics — Does it accomplish the aesthetic goal(s)?	Exceeded project requirements by using embedded thin-brick and sandblasted, medium-exposure precast often in the same panel.
Environmental Impacts — More or less?	The reduction in site impact alone reduces the environmental impacts. Also there is a good opportunity to use recycled material in both the concrete and the steel used to fabricate the panels, and of course the reduction in energy use.
Indoor Environmental Quality — Does it improve or reduce IEQ?	Precast eliminates a cavity between outer and interior walls, does not provide food source for mold, no VOCs, = improved IEQ.
Revenue Generation — Linked to schedule, does the project complete faster? If so, what is the revenue/per week for the owner?	Not applicable for this project since the project had to be completed for the next school year. Missing the deadline however, would have cost the university millions of dollars.
Design and Construction Complexity — Does it make it easier to design and construct? Is the change adding trades, detailing, connections, and maintenance concerns?	Reduced trades and detailing = reduced complexity. An architect can tell you that the installation of the building envelope by one trade made our work in the field significantly easier. The system is virtually foolproof and does not require multiple site visits and reports on progress with inevitable punch list items for the contractor to correct—results in time saving of 10%.
Risk Management — Increasing or reducing risks? Liability for designer, contractor, owner, public, occupants?	Precast reduced overall risk and design complexity—reducing design, coordination and inspection time by 15%. For example: built in vapor barrier and ci, which cannot be damaged in the field by sloppy construction techniques, no weather delays, tighter tolerances, etc.
Durability and Resiliency — Is the change improving durability? Is it improving resiliency? Does increase service life?	Precast exceeded the 50-year service life requirement, at a lower life-cycle cost.

Net Results

The precast envelope system option saved 60 days, and $1,200,000 of first costs—including time spent on design, inspection, etc. The precast option is projected to save the owner about $58,000 on an annual basis over the next 50 years = $2,900,000 in today's dollars.

Often a thorough analysis will expose several factors that may not have been obvious at first glance. This can result in substantial savings for an owner, contractor, the public, and all stakeholders, as well as the environment. So the next time you have an opportunity to evaluate an alternate option, what approach will you use?

For more information on these or other projects, visit www.pci.org/ascent.